

Reflection of hedonic price changes would widen the downward trend in LEC input prices relative to economy-wide price changes.

The capital input price indexes used by Christensen — the Telephone Plant Indices (TPIs) — make no adjustment for changes in the nature of the input over time. By assuming that the nature of each of the items included within the TPIs remain constant, the TPIs fail to reflect changes in the character of the plant under study from one year to the next. Where the nature of the input is relatively stable — e.g., office furniture — this type of index may provide useful results. However, for many of the types of capital inputs used by LECs, i.e., inputs containing computer chips, digital electronics, fiber optics, digital switching equipment, and other high-technology items whose specifications and characteristics have evolved rapidly over time, the adjustment of price indexes to properly account for changes in quality and/or capacity is very significant. Indeed, failure to do so may have the effect of overstating price level increases and/or understating price decreases. In the economics and statistics literature, such adjustments for changes in quality and/or capacity are referred to as *hedonic* adjustments. Failure to make hedonic price adjustments will necessarily overstate input price growth and result in an X-factor that is misspecified and biased downward.

Recognition of hedonic-adjusted price changes is well-established in the economics literature. The Bureau of Economic Analysis (BEA) of the US Department of Commerce and the Bureau of Labor Statistics (BLS) have long recognized the importance of including quality change measurements in price indexes. BLS has studied hedonic methods as a way of dealing with quality change since the 1960s. Hedonic methods were first accepted and used in 1968 in the price index of new single-family houses. This index is currently also used as a proxy to deflate various construction activities. Hedonic methods won official acceptance in 1986, when the BEA announced a revision of the US National Income and Product Accounts to incorporate the use of a new computer equipment price index based upon hedonic methods. As a result, the BEA began using the hedonic price indexes of computers for deflation within the National Income and Product Accounts. By doing this, the BEA aimed at creating a better measurement to capture the effects of rapid technological advances in the computer market.

Failure to recognize quality effects in the capital input price indexes creates two separate, but not unrelated, sources of bias — the “substitution bias” and the lack of measurement of quality change. Substitution bias occurs because the weights in the index are based upon input expenditure patterns from prior years. As a result, the price index does not reflect changes in buying patterns in response to changes in relative prices. For example, “...even if the price of cellular phone calls drops relative to the price of postage stamps, so that consumers make more cellular phone calls and send fewer letters, the relative weight of cellular phones and postage stamps in the CPI will be based on expenditures in some

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remote base year.”¹¹¹ As another example, “the ability of firms using electronic components to substitute transistors for tubes, and then integrated circuits for transistors, and then successively more powerful integrated circuits for less powerful circuits, is not taken into account at all” in price indexes unadjusted for quality changes.¹¹²

Quality change bias occurs when improvements in the quality of products are inadequately measured or not measured at all. In fact, quality change measurements are basically non-existent. Changes in quality of new goods and services are not accounted for. Therefore, a bias occurs when a good is replaced by a new or improved good. For example,

“...if the price of a tire increases but the quality of the tire is improved, then the change in the cost of living cannot be measured as simply a change in price. If the price doubles but the tire lasts twice as long, and other important qualities of the tire (traction, ride, and the like) are also better, then the quality-adjusted price change may in fact be zero or even negative.”¹¹³

These biases have a direct impact on the various measurements that use price indexes, including productivity. Indeed, a recent report by the Advisory Commission to Study the Consumer Price Index suggested that when adding all the estimates of each source of CPI bias, the CPI overstated the actual rate of inflation by about 1.5% per year, with the quality change bias alone estimated at 0.2 to 0.6 of the total source of bias.¹¹⁴ In recent years, there has been extensive debate about the negative impact to the economy of the so-called “CPI bias.” Most economists agree that the CPI has been inflated due to methodological

111. Gordon, Robert J.. “Measurement Errors in the CPI: Causes and Consequences,” *Northwestern University and National Bureau of Economic Research*, Testimony presented before Senate Finance Committee, March 13, 1995 at 3.

112. Robert Gordon, “The Measurement of Durable Good Prices,” University of Chicago Press, 1990, page 30. Gordon notes, as a consequence, that there was no accounting for the implicit price reduction that the invention of these new components implied, and that “the late introduction of integrated circuits as a totally new product and the use of obsolete weights helped account for the remarkable fact that the PPI group index (1178) for “electronic components and accessories” displays a 1967-83 price increase, while the price of virtually every type of final electronic product covered in this study (computers, PCs, electronic calculators, electronic typewriters, VCRs) declines at a double digit annual rate during the same interval.

113. O'Neill, June E., “Statement of June E. O'Neill Director Congressional Budget Office on the Consumer Price Index before the Committee on Finance United States Senate,” Congressional Budget Office Testimony, March 13, 1995 at 8.

114. “Toward a More Accurate Measure of the Cost of Living,” Interim Report to the Senate Committee from the Advisory Commission to Study the Consumer Price Index, September 15, 1995 at Executive Summary and page 27.

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problems, particularly related to the failure of the CPI to incorporate hedonic adjustments. The CPI bias is also manifest in other indexes, such as the GDP-PI, that incorporate the CPI.¹¹⁵

The BEA's efforts to create more objective and accurate measurements have led to the recent announcement of a comprehensive revision of the national income and output accounts due at the end of 1995. The revision will result in new improved measurements of output and prices, using chain-type annual-weighted indexes. These improvements have been designed to deal particularly with the above described substitution bias. According to a recent article, "[b]y minimizing the substitution bias, the new measures of real GDP growth will also improve analysis of issues such as productivity, returns to investment, and the long-term growth potential for the economy."¹¹⁶

Hedonic price indexes are an attempt to measure changes in the characteristics of specific commodities. As alluded to above, much of the recent work in this field has focused on the computer industry — one of the fastest growing industries and one with rapid growth in technological change, both in terms of quality and capacity of the products.¹¹⁷ According to one study, "...the quality-adjusted real prices for personal computers

115. For a discussion of the several causes of bias in the CPI, see, Diewert, Erwin W.. Written Testimony for the United States Senate Committee on Finance, April 6, 1995; Gordon, Robert J.. "Measurement Errors in the CPI: Causes and Consequences," *Northwestern University and National Bureau of Economic Research*, Testimony presented before Senate Finance Committee, March 13, 1995; O'Neill, June E.. "Statement of June E. O'Neill Director Congressional Budget Office on the Consumer Price Index before the Committee on Finance United States Senate," Congressional Budget Office Testimony, March 13, 1995; and "Toward a More Accurate Measure of the Cost of Living," Interim Report to the Senate Committee from the Advisory Commission to Study the Consumer Price Index, September 15, 1995.

116. Landefeld, J. Steven and Robert Parker. "Preview of the Comprehensive Revision of the National Income and Product Accounts: BEA's New Featured Measures of Output and Prices," *Survey of Current Business*, July 1995.

117. See, e.g., Ernst R. Berndt, Zvi Griliches and Neal J. Rappaport. "Economic Estimates of Price Indexes for Personal Computers in the 1990's," *Journal of Econometrics*, Vol. 68, 1995, pp. 243-268; Berndt, Ernst R. and Zvi Griliches. "Price Indexes for Microcomputers: An Exploratory Study," Chapter 2 in Murray F. Foss, Marilyn E. Manser and Alan H. Young, eds., *Price Measurements and their Uses*, Studies in Income and Wealth, Vol. 57, University of Chicago Press, 1993; Cohen, Jeremy Michael. "Rapid Change in the Personal Computer Market A Quality-Adjusted Hedonic Price Index 1976-1987," S.M. thesis, Alfred P. Sloan School of Management, Massachusetts Institute of Technology, May, 1988; and Cole, Rosanne, Y.C. Chen, Joan A. Barquin-Stollemen, Ellen Dulberger, Nurhan Helvacia and James H. Hodge. "Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment," *Survey of Current Business*, January, 1986.

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have been dropping at an annualized cumulative rate of about 25%.”¹¹⁸ Another study found that since the late 1950s the trend in annual decline may have been as high as 28% for mainframe computers of a given speed and capacity, and noted the widespread belief within the industry that for supercomputers and for minicomputers and microcomputers the decreases may have been even greater.¹¹⁹ Yet another more recent study on personal computers in the 1990s concluded that “...on average these quality-adjusted price indexes based on econometrically estimated hedonic price equations decline at about 30% per year.”¹²⁰ The official BEA price index for the commodity aggregate of computers and computer-peripheral equipment types, based largely on hedonic regression procedures, continues the steady decline over time revealed for the period 1953-1972: Over the 1972-1984 era, the average annual growth rate (AAGR) of this quality-adjusted price index is -13.8%.¹²¹ Moreover, if one combines the results for the 1953-1972 time interval with those for the 1972-1984 epoch, one finds that quality adjusted computers that cost \$531.88 in 1953 cost only \$1.00 in 1982; in other words, what would have cost more than a half a million dollars in 1953 cost only \$1,000 in 1984.¹²² Moreover, since the calculations involve only mainframe and minicomputers and exclude personal (micro) computers, it is possible that this price index understates the amount of quality improvement.¹²³

Clearly, the importance of accurate and objective indexes for telecommunications inputs is of particular concern in the development of a TFP-based long-term price cap plan. Indeed, as noted in an important work on technological advance in the telecommunications industry: “In terms of technological intensity, measured by R&D investment as a percentage of sales, communications equipment (at 9 percent) is second only to computers (at 12

118. Cohen, Jeremy Michael. “Rapid Change in the Personal Computer Market A Quality-Adjusted Hedonic Price Index 1976-1987,” S.M. thesis, Alfred P. Sloan School of Management, Massachusetts Institute of Technology, May, 1988 at 62.

119. Kenneth Flamm, “Technological Advance and Costs: Computers versus Communications,” in Robert W. Crandall and Kenneth Flamm, Eds. *Changing the Rules: Technological Change, International Competition, and Regulation in Communications*, The Brookings Institution/Washington, D.C., 1989, page 16.

120. Berndt, Ernst R., Zvi Griliches and Neal J. Rappaport. “Economic Estimates of Price Indexes for Personal Computers in the 1990’s,” *op cit*, 1995.

121. Ernst Berndt, *The Practice of Econometrics: Classic and Contemporary*, “The Measurement of Quality Change: Constructing an Hedonic Price Index for computers Using Multiple Regression Methods,” (Chapter 4). Addison-Wesley Publishing Company, 1991, page 125.

122. *Id.*, pages 125-126.

123. *Id.* page 126.

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percent) among America's commercial high-technology industries."¹²⁴ Another key study identifies electronic computers and electronic telephone switching systems as two "technologically progressive products...characterized by new model introductions in which performance is improved relative to price."¹²⁵ This study notes in particular the substantial increases in carrying capacity made possible by new model introductions of both transmission and switching technologies that have resulted in unmeasured price declines over the years.¹²⁶ LEC capital inputs continue to be characterized as technologically progressive and by new model introductions, making it overwhelmingly evident that quality changes are an important component of productivity growth in the telecommunications industry.

Yet neither historic nor current measurements of LEC capital input prices used by LECs capture technology-driven capacity and capability improvements. The TPIs that were developed by each of the LECs participating in the USTA/Christensen study do not reflect quality or capacity changes that affected the various capital input categories during the 1984-92 period.¹²⁷ By failing to reflect quality characteristics, the ending values for the TPI data series incorporated in the Christensen study are consistently and systematically biased in the upward direction.

As noted in a study which examined TPIs of the pre-divestiture Bell System:

No allowance is made for changes in price per unit of the desired quality characteristic, that is, per circuit mile for transmission equipment or line capacity for a switching system. In effect, only price changes following the initial introduction of a new model have any effect on the aggregate TPI. We learned in studying computer prices that much of the rapid rate of price decline measured by hedonic price indexes occurs with the introduction of new models, and the evidence of Cole et al. (1986) was cited showing that a matched model index for computer processors declined during 1972-84 at a much slower rate than a hedonic regression index. It would be surprising if price declines in telephone equipment did not also occur with the introduction of new models.¹²⁸

124. Kenneth Flamm, *op cit*, page 13.

125. Robert J. Gordon, *op cit*, page 29.

126. *Id.*, pages 398-399.

127. The same is true of the historic input price growth data presented by USTA's economic consultants to support their assertion that the long run LEC input price differential is zero.

128. *Id.*, page 398.

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This same criticism applies to the post-divestiture TPIs developed by the LECs and incorporated in the Christensen study.

The study also identifies numerous other unmeasured aspects of quality change not taken into account in price indices for telephone plant, providing further support for the notion that TPIs developed by the LECs understate the "true" rate of price decline. With respect to technological advances in switching equipment:

- First, reduced maintenance cost and energy use in electronic switching systems creates value for the user beyond the sheer carrying capacity of the switches. In addition to these savings, electronic switching equipment has made possible radical reductions in equipment space occupied per line served, thus allowing many telephone companies to eliminate whole multistory buildings that would have been required with the previous technology to accommodate today's calling volumes.
- Second, for switching equipment, the basic measurement unit is taken to be the "line," but a telephone line is not the same as it was twenty or forty years ago. Today's switches allow calls to be completed much faster than before, saving time for customers, and the programming capabilities of modern switches allow the equipment to search for alternative routings, thus reducing the incidence of "circuit busy" signals.
- Third, today's digital switches (by converting analog voice signals into digits) reduce distortion and provide a clearer line.
- Finally, modern switches allow the provision of additional services, including the routing provision of itemized bills for subscribers, as well as paging and electronic call transfer services.¹²⁹

The technological advances noted by the study were by no means limited to switching equipment. The study found that "the transition to fiber optic cable must have created a decline in the effective cost of transmission equipment during this period even more rapid than that of switching equipment," citing a rate of price decline for fiber optic cable of 45 percent per year from 1980 to 1985.¹³⁰

129. *Id.*, pages 403-404.

130. *Id.*, page 404.

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There are several implications of this discussion of quality effects for the results of the USTA/Christensen TFP study and its application to the X-factor:

- By overstating the growth in the TPIs or asset price deflators used to develop capital input price and quantity indices over the study period, a slightly overstated value for the TFP is likely to result.
- However, the more predominant effect under the USTA/Christensen approach, is that by overstating the growth in input prices, the differential between LEC input price level growth and economywide input price growth is understated.

As noted above, this Report does not develop specific hedonic adjustments to use in the calculation of the X-factor. However, sensitivity analysis of Christensen's results indicates that incorporation of hedonic price adjustments would result in a significantly higher X-factor. These results confirm the necessity of taking hedonic effects into account in the calculation of the X-factor for a long-term price cap plan — if not directly with the use of explicit hedonic price deflator series,¹³¹ then indirectly by the Commission's adoption of a compensating input price adjustment and consumer productivity dividend.

Sources of LEC input price data

The Commission seeks comment on whether there are other sources of LEC input price data that could be used to calculate the input price differential that would be preferable to the data used in the Christensen/USTA study.¹³² In addition, the Commission seeks comment regarding the development of a telecommunications specific input price index.¹³³

Section 2 of this Report discusses in detail the empirical problems with the data used in the Christensen/USTA study. In this section of the Report, we identify other sources of data that can be used to develop input price data for the LECs that would involve objective, auditable data series, for example BEA/BLS asset deflator data in lieu of LEC TPI data, and net book value capital stock in lieu of replacement capital stock. However, the problems we identify concerning the input data used in the Christensen/USTA study impact the overall validity of the study; they discredit the TFP results calculated using that input data as much as the input price differential derived from that data. The basis of Ad Hoc's argument that the LEC input price data should be derived from data used in the Chris-

131. With additional time and resources, more precise quantitative measures can (and are) being developed.

132. FFNPRM, para. 59-60.

133. *Id.*, para.60.

CERTIFICATE OF SERVICE

I, Kurt A. Kaiser, hereby certify that on this 11th day of July 1997, true and correct copies of the preceding Petition for Reconsideration on behalf of Ad Hoc Telecommunications Users Committee in CC Docket Nos. 94-1 and 96-262 were served by hand delivery upon the following parties:

James Schlichting
Chief
Competitive Pricing Division
Common Carrier Bureau
Federal Communications Commission
1919 M Street, NW.
Room 518
Washington, D.C. 20554

ITS
1919 M Street, NW.
Room 246
Washington, D.C. 20554


Kurt A. Kaiser

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